Transmission line based decoupling methods for MIMO and phased arrays

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Biography

Shuai Zhang received the B.E. degree from the University of Electronic Science and Technology of China, Chengdu, China, in 2007 and the Ph.D. degree in electromagnetic engineering from the Royal Institute of Technology (KTH), Stockholm, Sweden, in 2013. After his Ph.D. studies, he was a Research Fellow at KTH. In April 2014, he joined Aalborg University, Denmark, where he currently works as Associate Professor. In 2010 and 2011, he was a Visiting Researcher at Lund University, Sweden and at Sony Mobile Communications AB, Sweden, respectively. He was also an external antenna specialist at Bang & Olufsen, Denmark from 2016-2017. He has coauthored over 60 articles in well-reputed international journals and over 15 (US or WO) patents. His research interests include: mobile terminal mmwave antennas, biological effects, CubeSat antennas, UWB wind turbine blade deflection sensing, MIMO antenna systems, and RFID antennas.

Abstract

As the key technologies in future 5G cellular communication systems, millimeter wave (mmwave) will be applied for 5G mobile handsets. In these systems, beam steerable arrays with high gain have to be utilized at both base stations and user terminals in order to overcome the path loss. In mobile terminals, there is very limited space left for 5G arrays after accommodating 2G, 3G and 4G antenna systems. The only power supply in a cellphone is a small battery, which requires low-loss and low-cost beamforming. Moreover, user's mobility and blockage also rise some more new issues. This presentation will introduce the challenges in mm-wave 5G mobile handsets. As some examples, recent progress of the antenna group at Aalborg University will be introduced in the area of mm-wave beam-steerable antenna arrays and their biological effects for 5G mobile terminals. In the base stations, massive MIMO is widely used in sub 6 GHz and in mmwave in the future. The mutual coupling between array elements is highly preferred to be lower than – 25 dB in consideration of active VSWR and system requirements. Moreover, the decoupling method should also be wideband and without significantly impacting the radiation patterns of array elements. This presentation will introduce a transmission line base method for isolation enhancement.

Index Terms:
mmwave antenna array, mobile handset, massive MIMO antenna, base station, mutual coupling, anechoic chamber

Outline

1. Background

2. Transmission-line-based decoupling network

3. Wavetrap structure for wide band decoupling

Background

Some recently published works

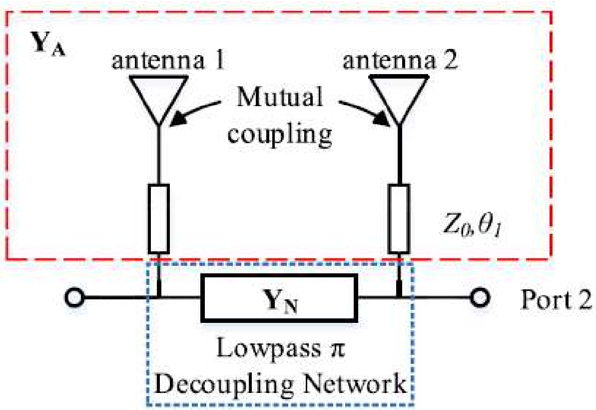

Fig. 1. *LC* Decoupling Network [1].

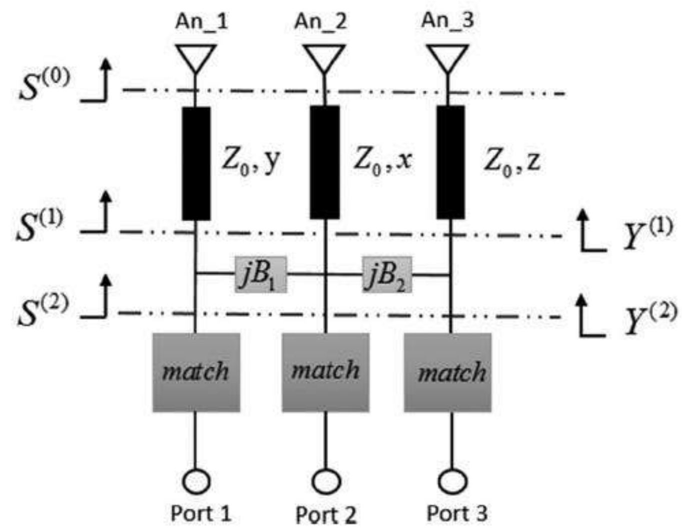

Fig. 2. Decoupling circuit for a three-element antenna array [2].

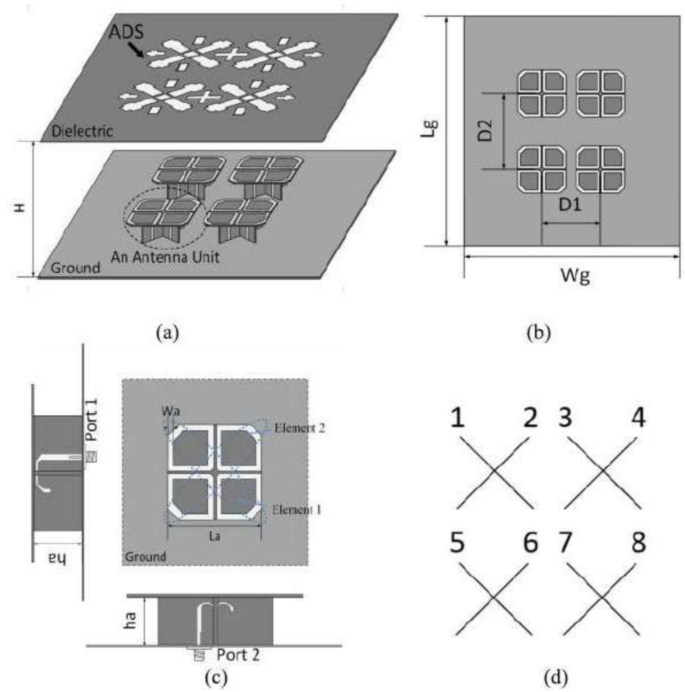

Fig. 3. Decoupling surface [3].

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[1] H. Meng and K.-L. Wu, "An *LC* decoupling network for two antennas working at low frequencies," *IEEE Trans. Microw. Theory Tech.*, vol. 65, no. 7, pp. 2321-2329, Jul. 2017.
[2] Y.-F. Cheng and K.-K. M. Cheng, "A novel and simple decoupling method for a three-element antenna array," *IEEE Antennas Wireless Propag. Lett.*, vol. 16, pp. 1072-1075, 2017.
[3] K.-L. Wu, C. Wei, X. Mei, and Z.-Y. Zhang, "Array-antenna decoupling surface," *IEEE Trans. Antennas Propag.*, vol. 65, no. 12, pp. 6728-6738, Dec. 2017.

1. Transmission-line-based decoupling network

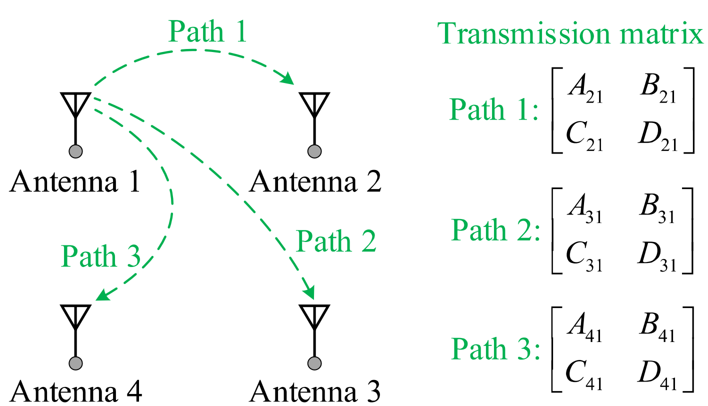


Fig. 4. Mutual couplings between antenna 1 and others within a 2×2 antenna array.

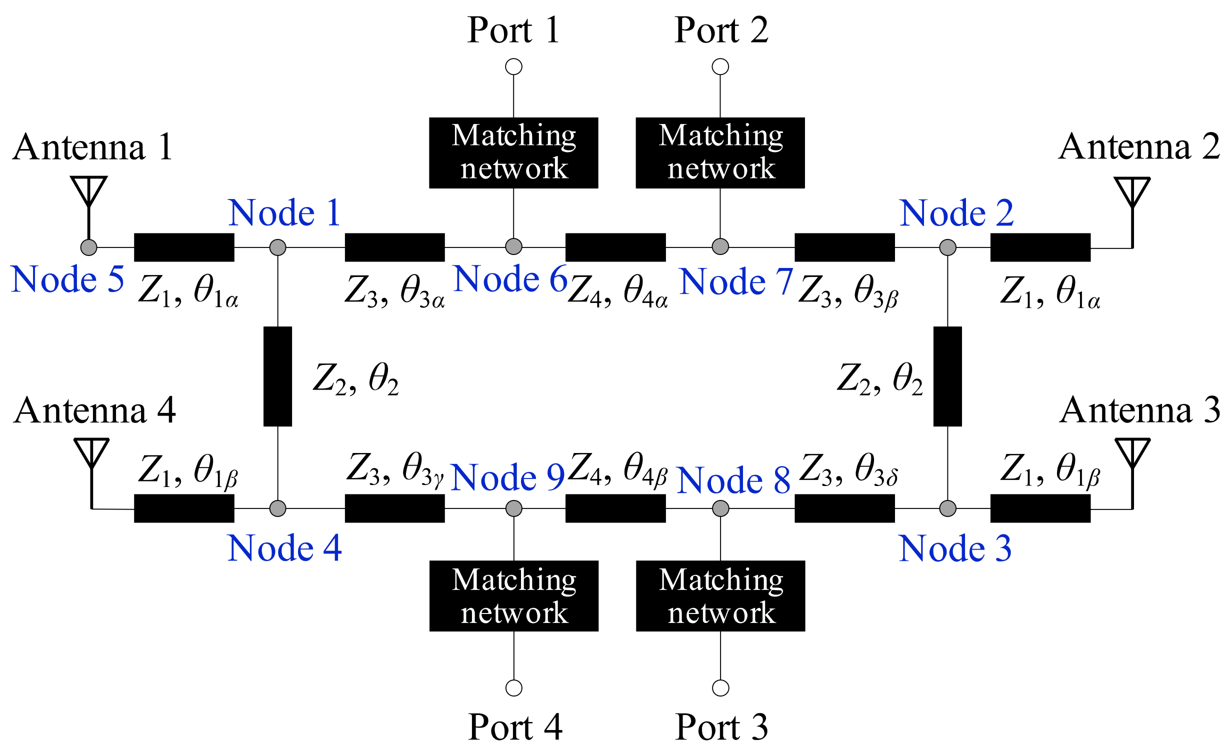


Fig. 5. Block diagram of the proposed decoupling network for 2×2 antenna arrays.

1. Transmission-line-based decoupling network

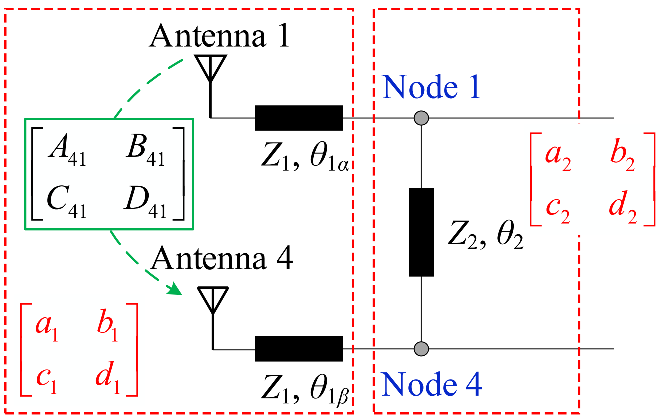


Fig. 6. Simplified circuit for the decoupling between antenna 1 and antenna 4.

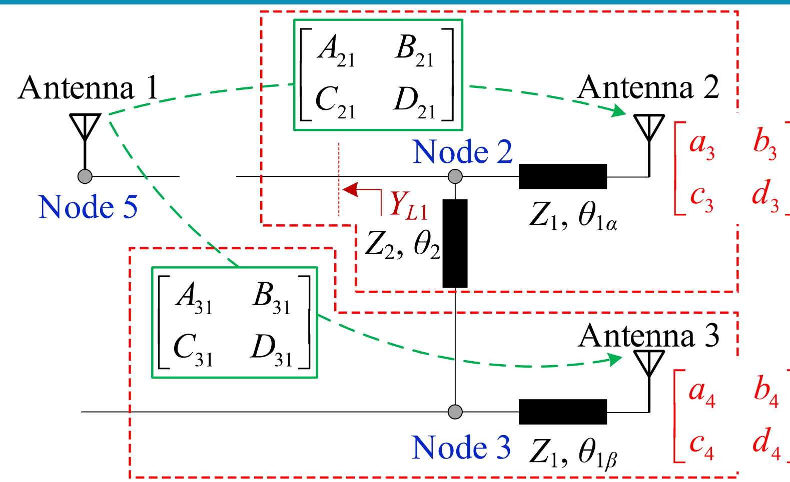


Fig. 7. Suppression network for the coupling between antenna 1 and antenna 3.

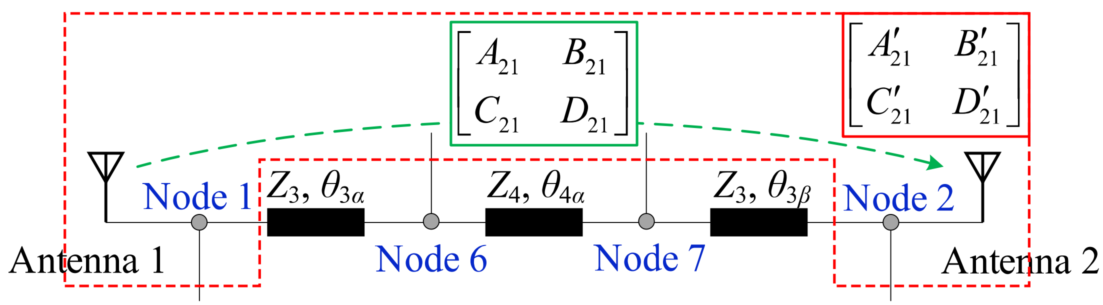
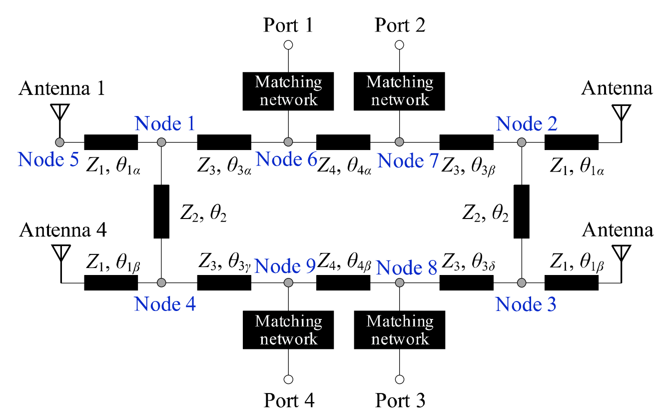


Fig. 8. Cancellation circuit for the coupling between antenna 1 and antenna 2.



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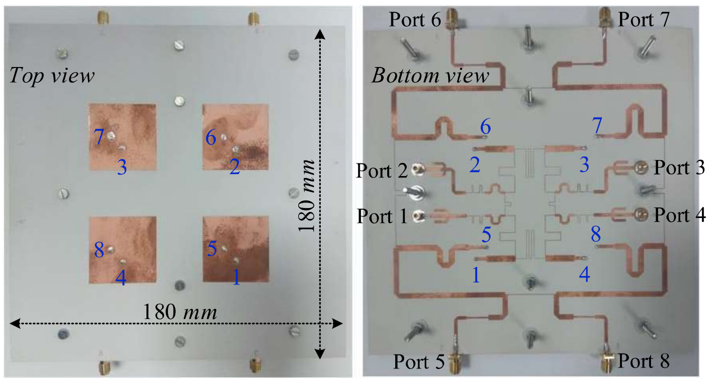
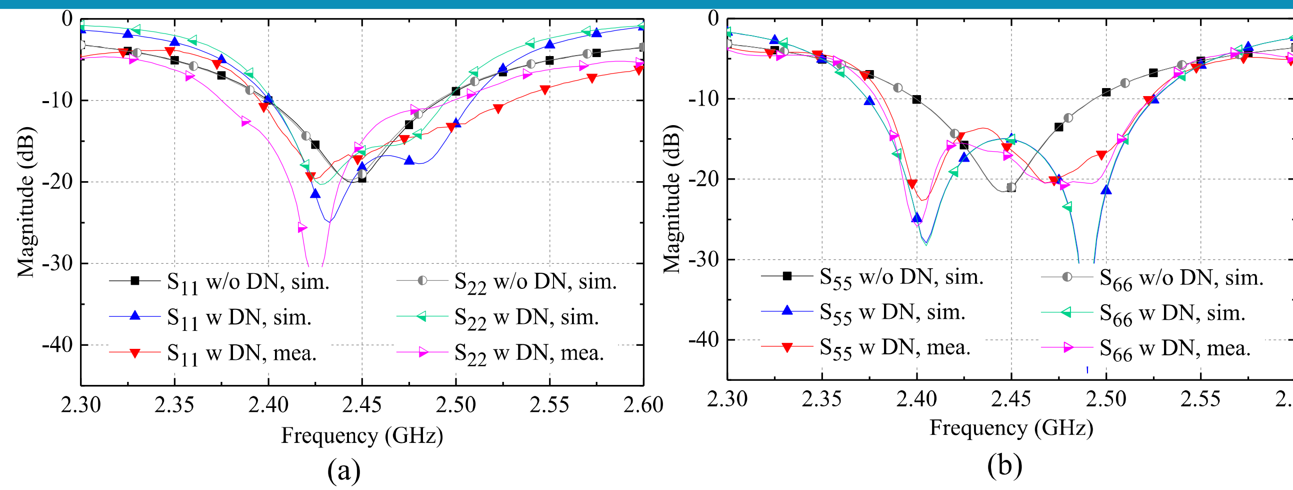


Fig. 13. Photographs of the 2×2 dual-polarized antenna array integrated with the proposed decoupling network.



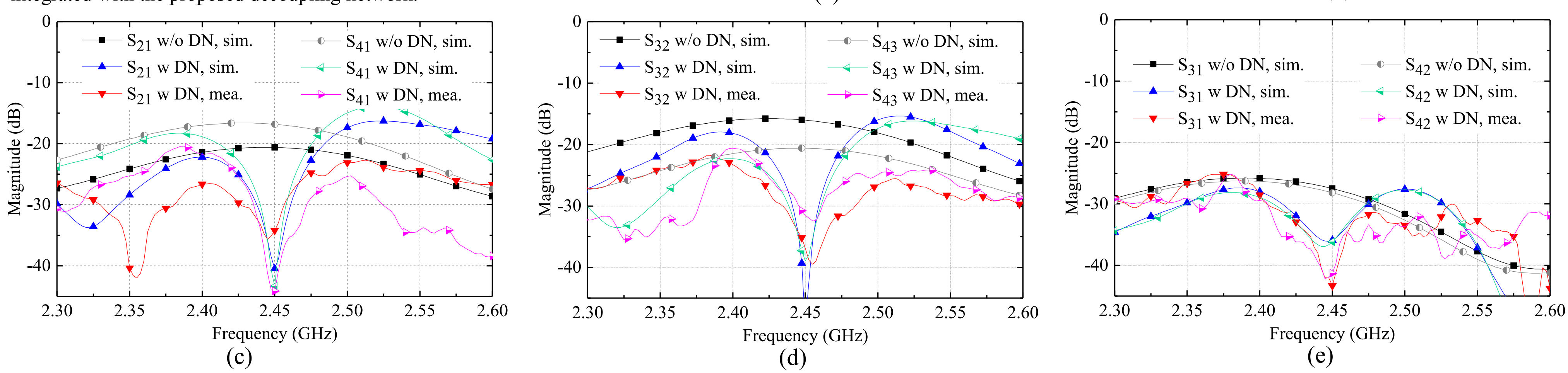


Fig. 14. Measured and simulated S-parameter of the developed prototype. (a) S_{11} and S_{22}. (b) S_{55} and S_{66}. (c) S_{21} and S_{41}. (d) S_{32} and S_{43}. (e) S_{31} and S_{42}.

1. Transmission-line-based decoupling network

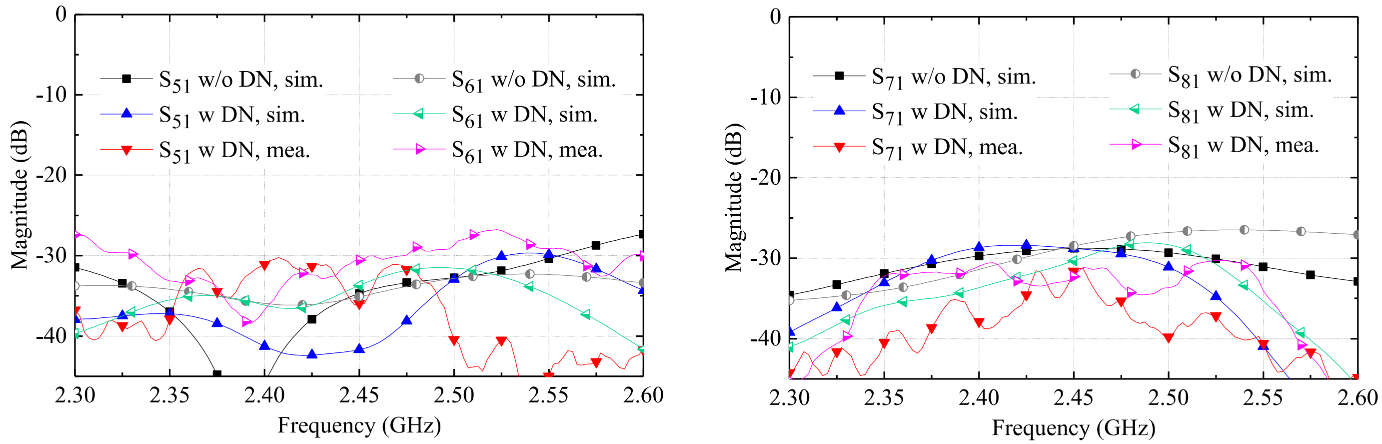


Fig. 15. Measured and simulated transmission responses between port 1 and ports 5-8.

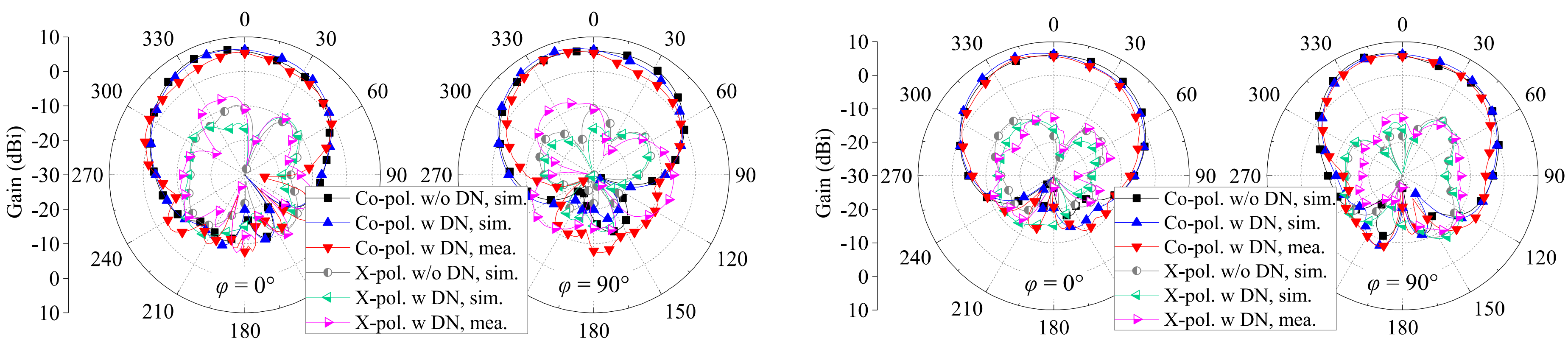


Fig. 16. Measured and simulated radiation patterns of some representative elements. (a) Port 1 and (b) Port 5.

1. Transmission-line-based decoupling network

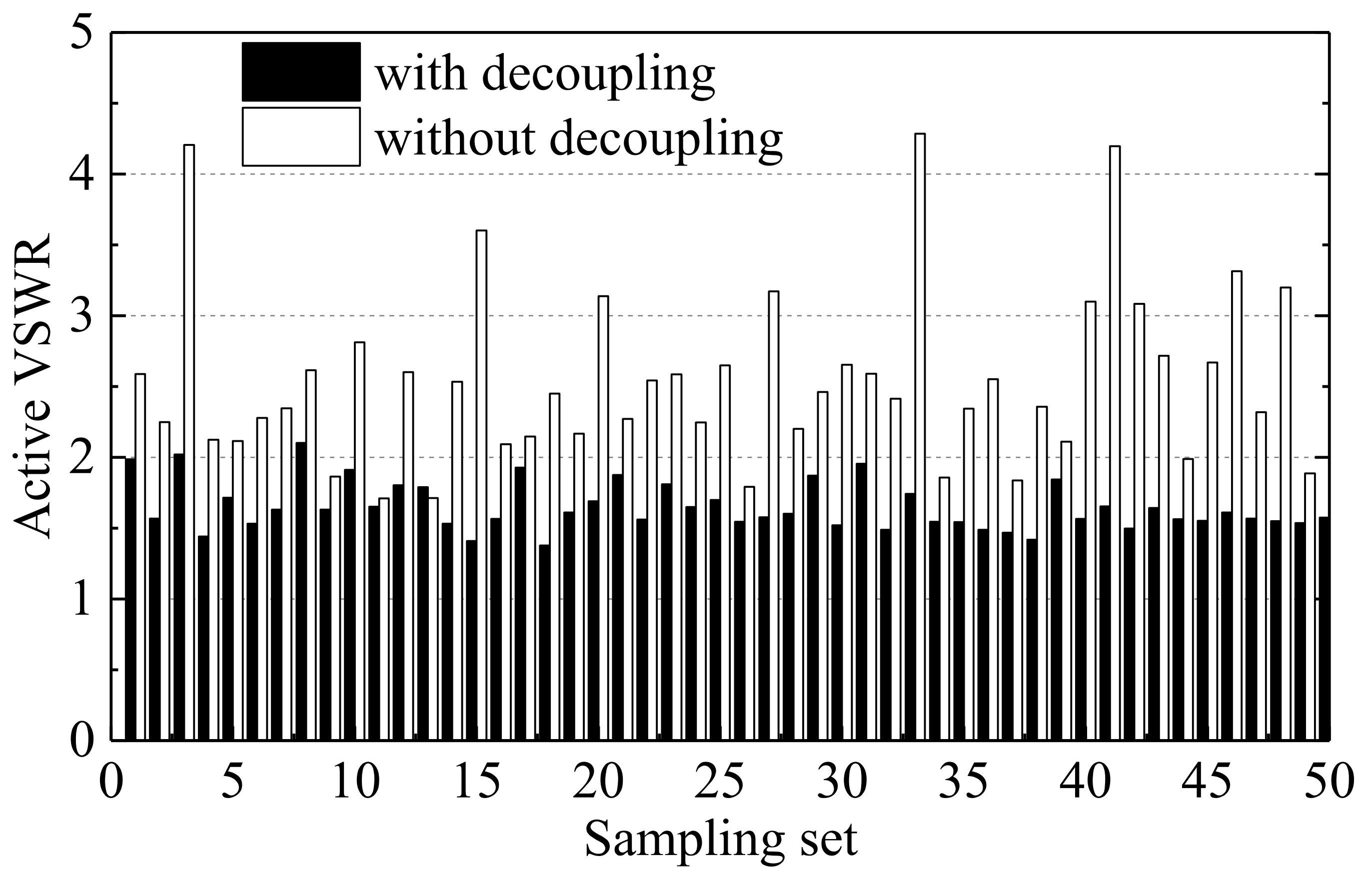


Fig. 17. Worst active reflection coefficients among the eight ports of the dual-polarized 2×2 array.

1. Transmission-line-based decoupling network: Decoupling for M×N MIMO

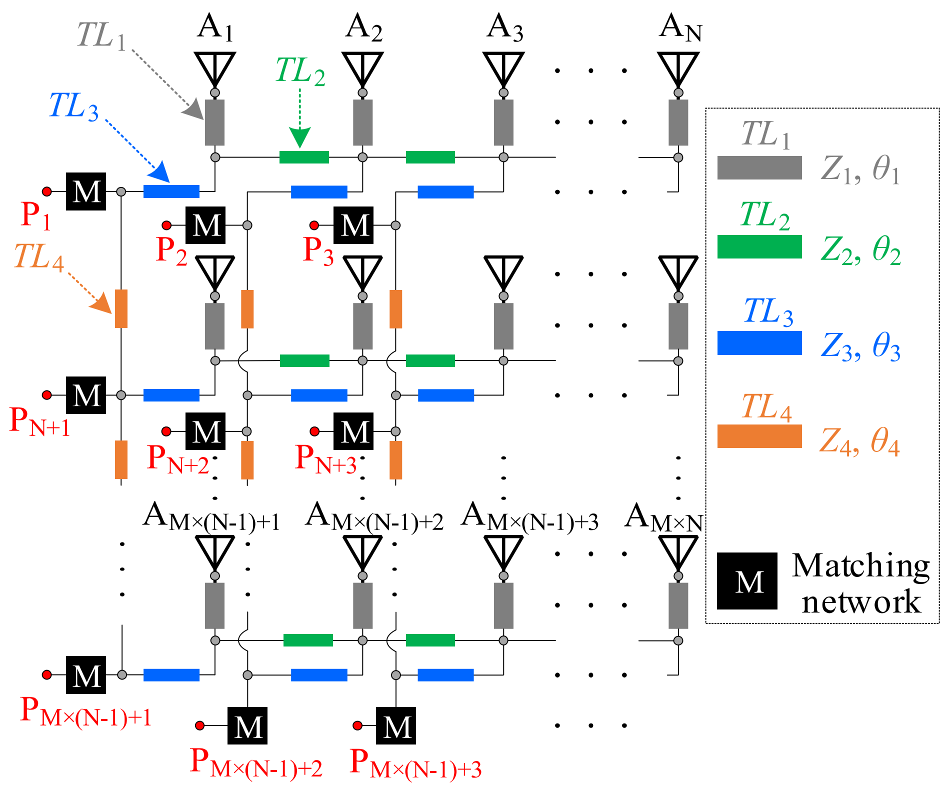


Fig. 18. Block diagram of the proposed decoupling network for M×N MIMO arrays.

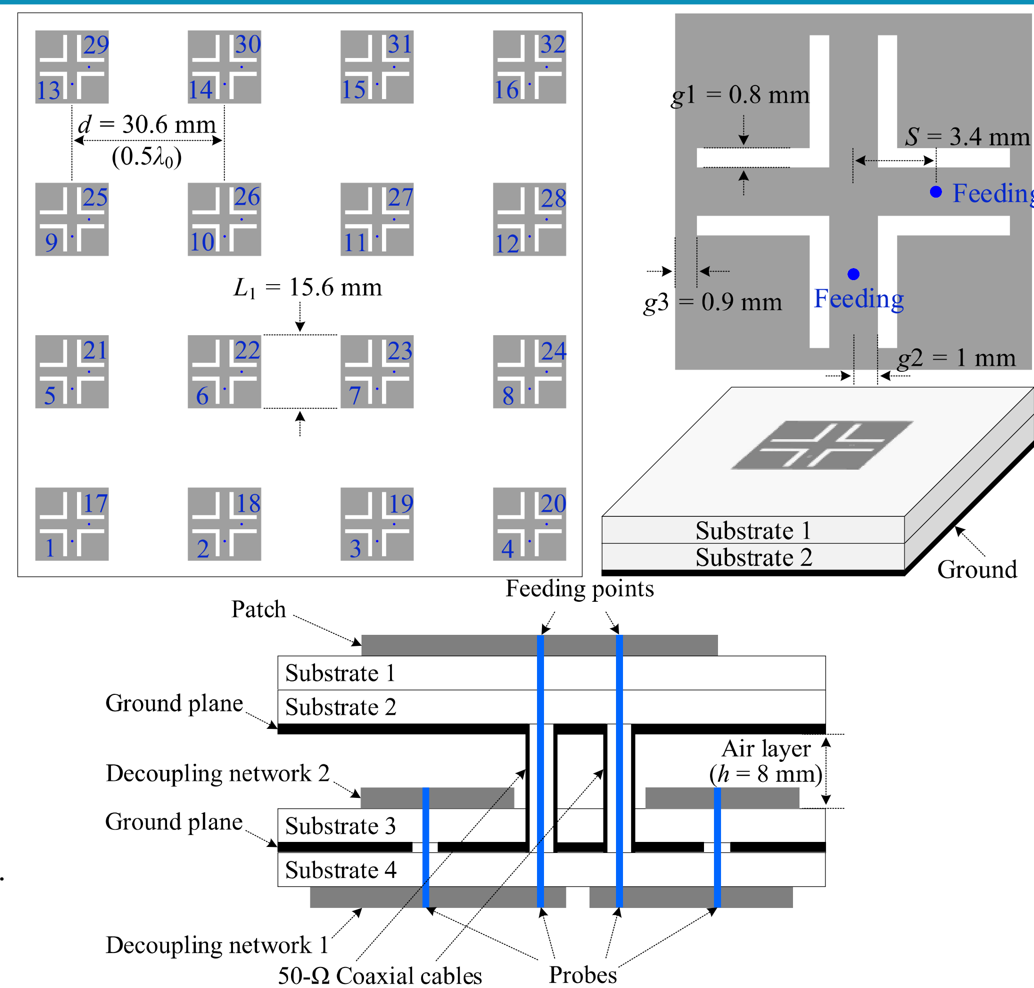


Fig. 19. Configuration of the dual-polarized 4×4 array.

1. Transmission-line-based decoupling network: Decoupling for M×N MIMO

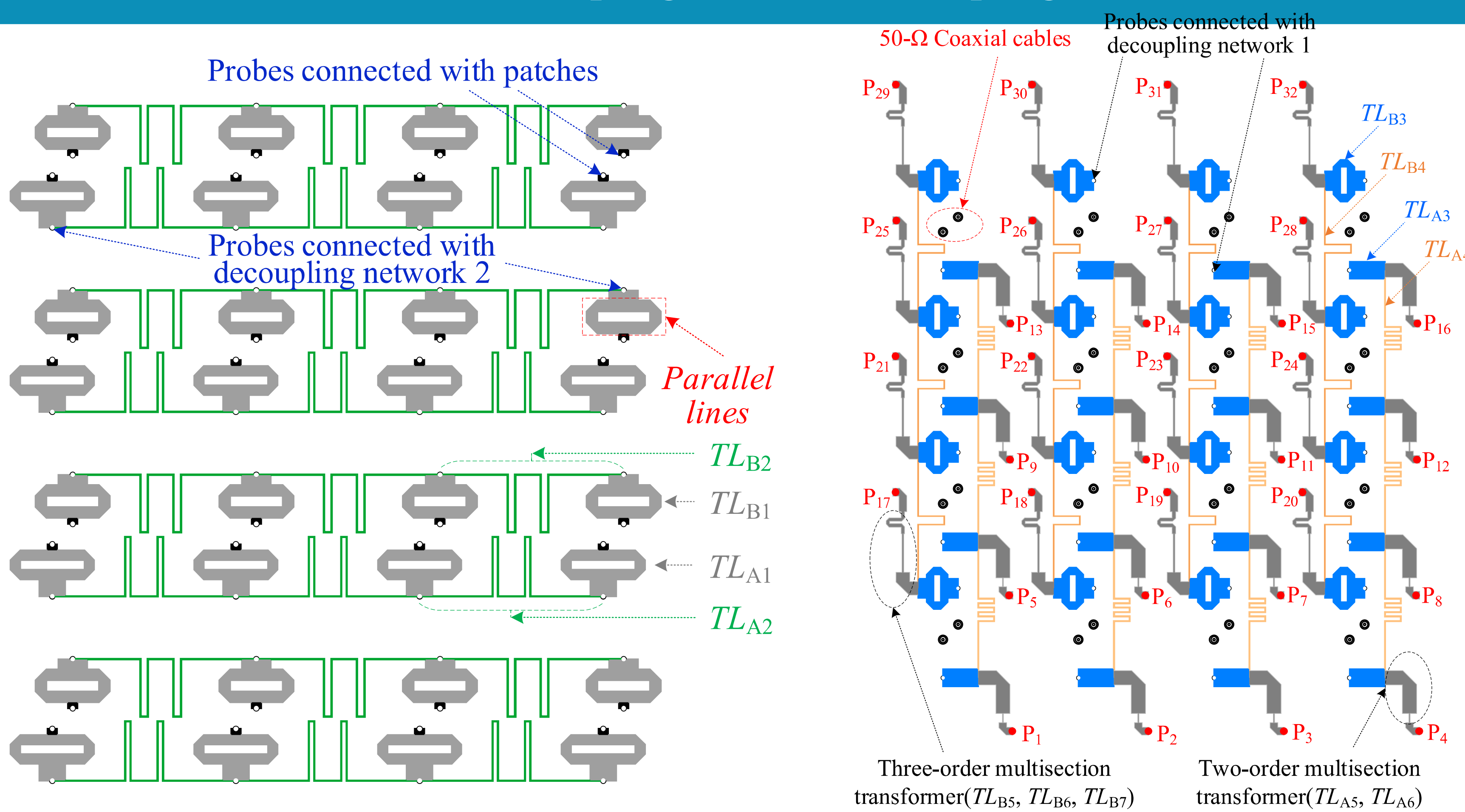


Fig. 20. Layout of the decoupling networks.

1. Transmission-line-based decoupling network: Decoupling for M×N MIMO

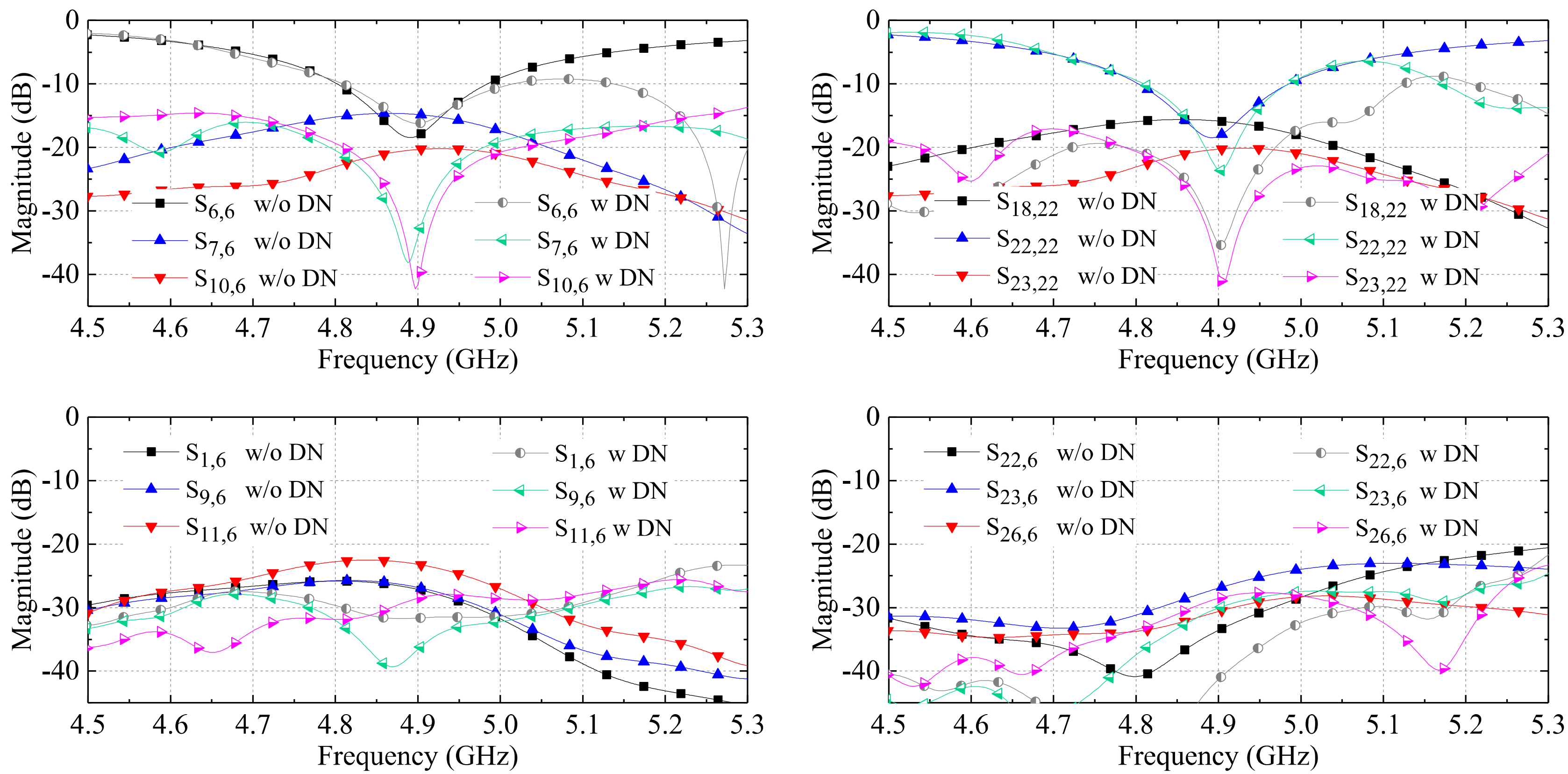
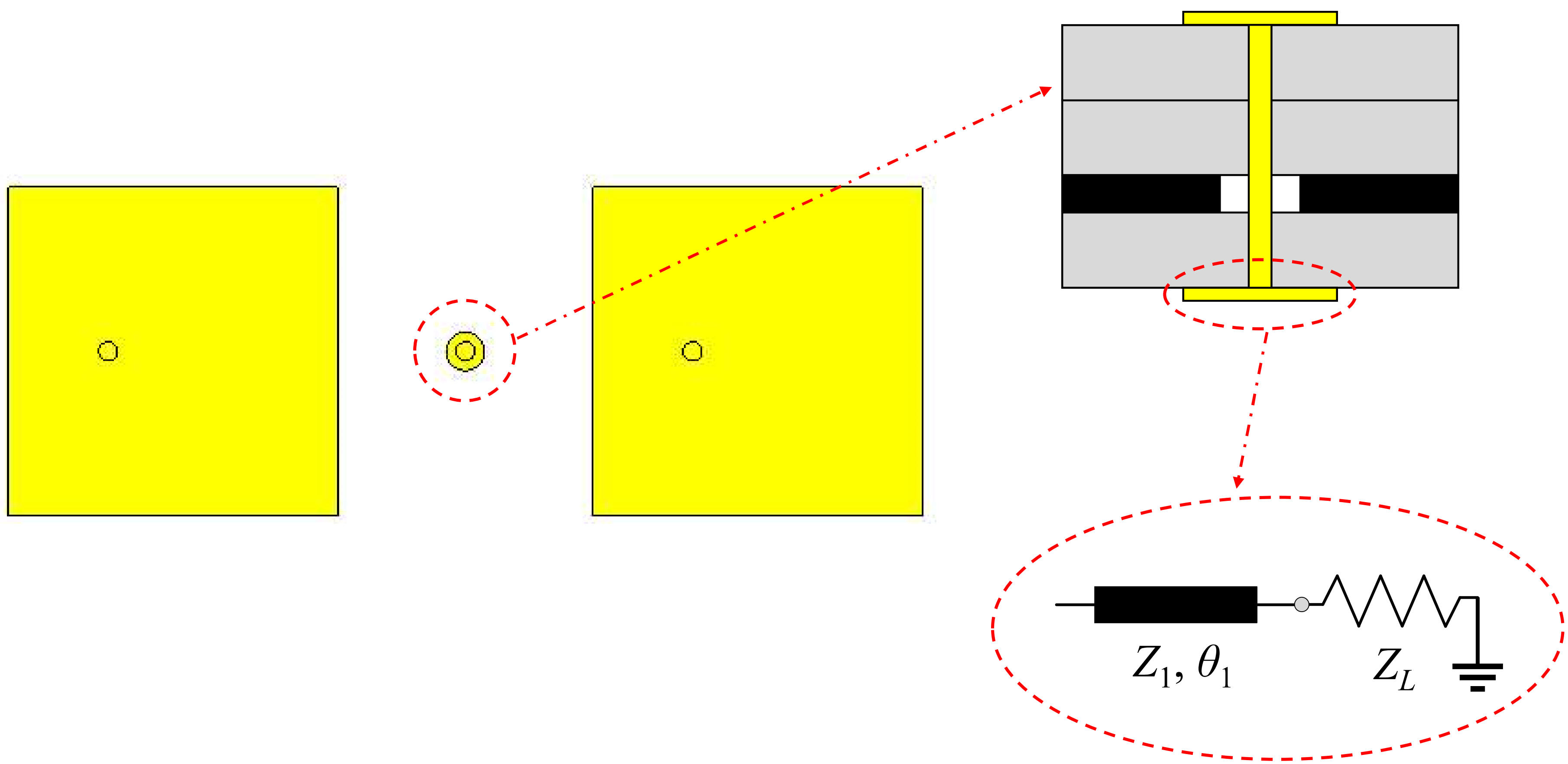


Fig. 21. Measured and simulated S-parameter of the developed prototype.

2. Wavetrap structure for wide band decoupling: Future Project



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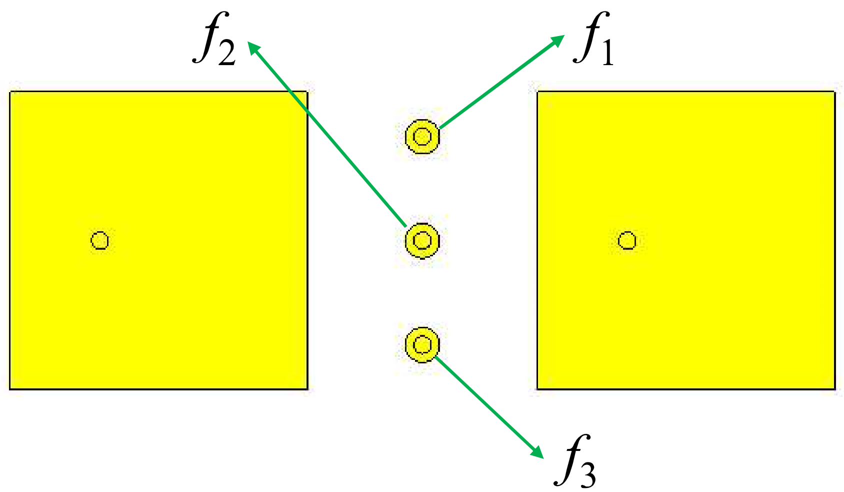

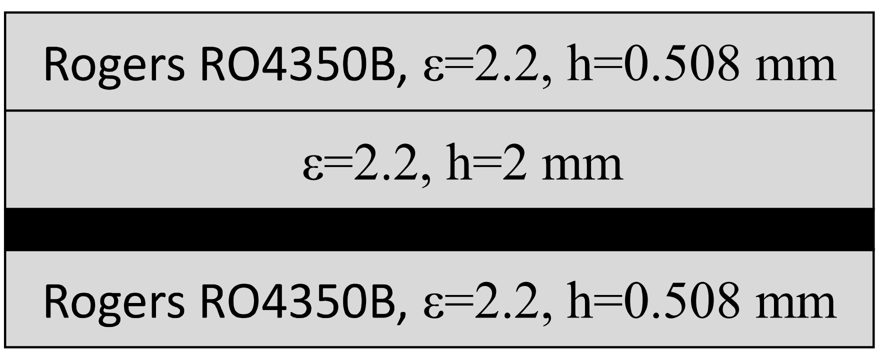

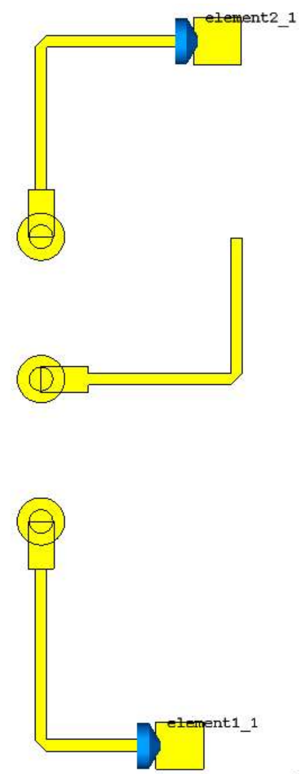

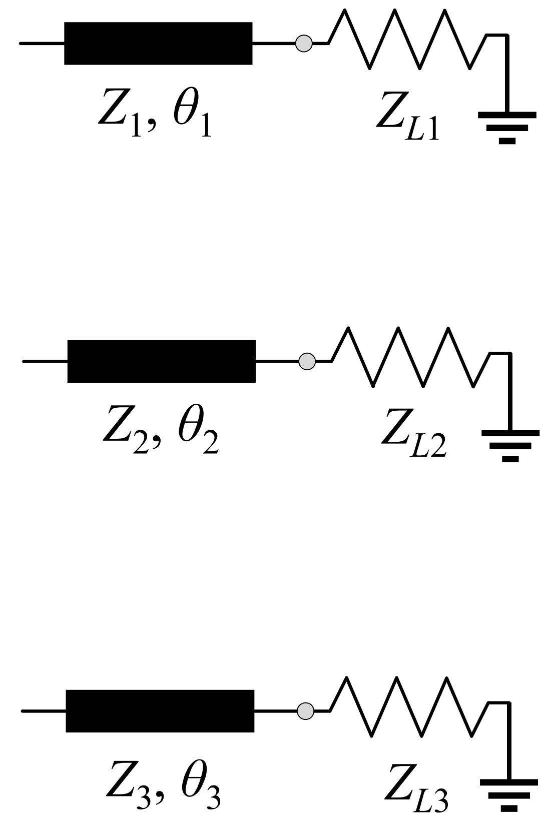

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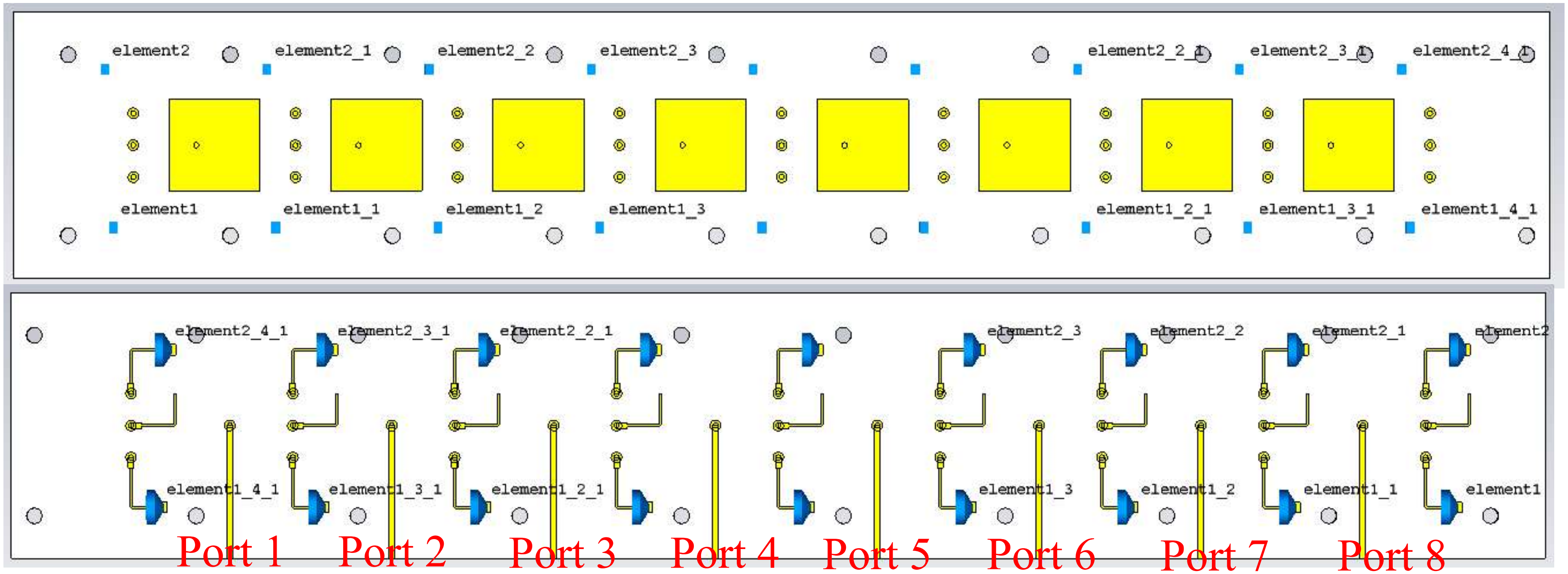

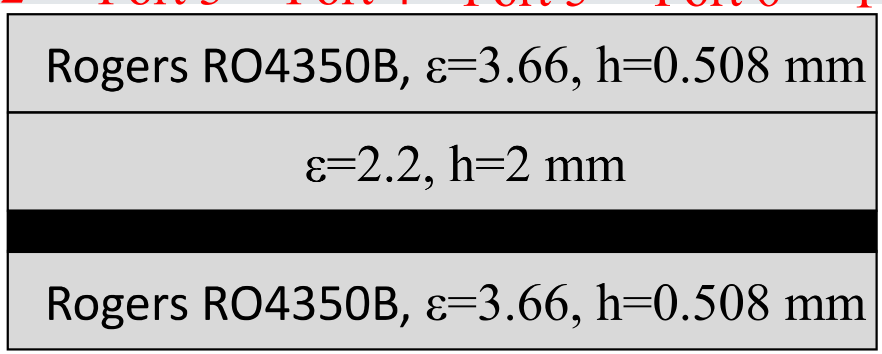

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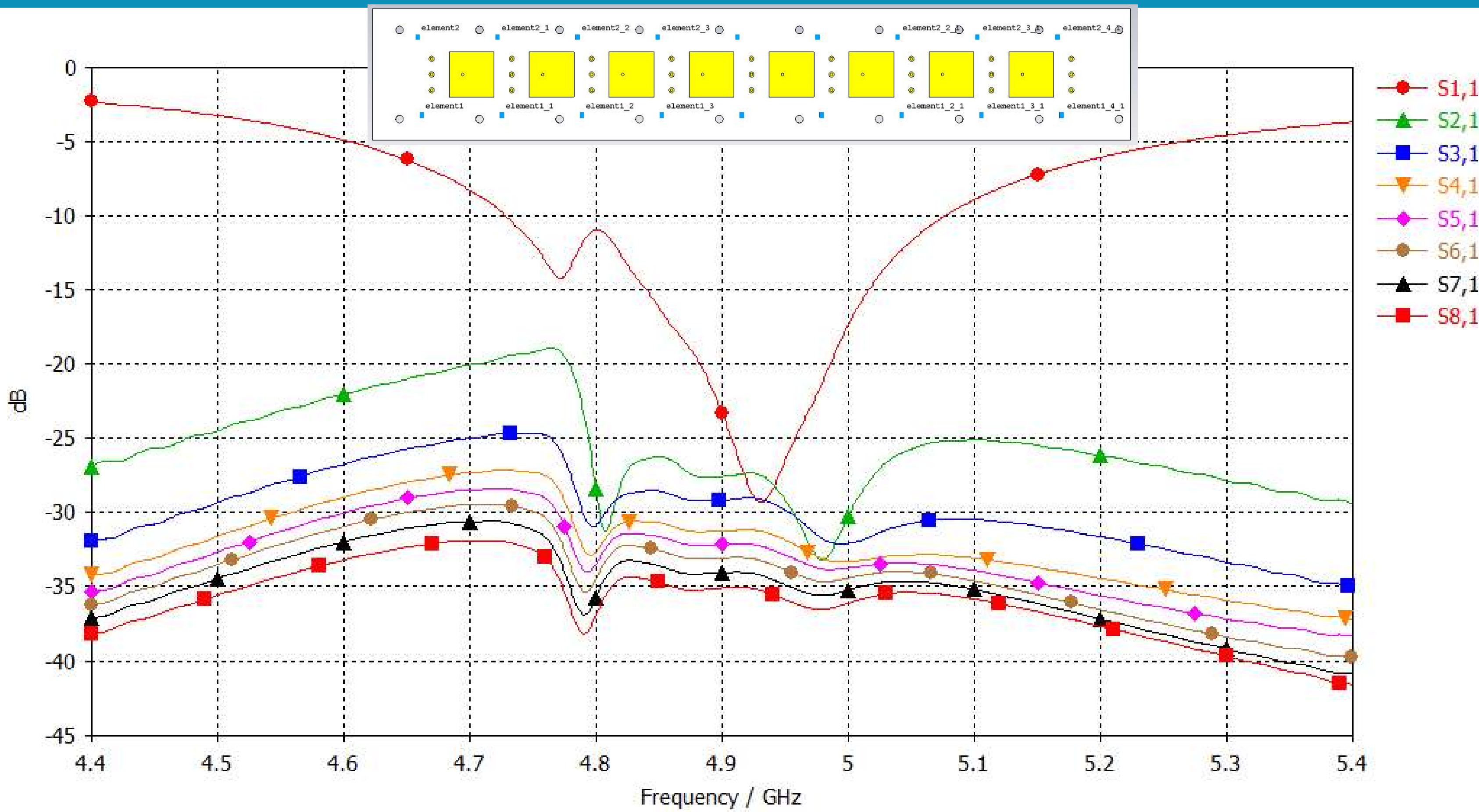

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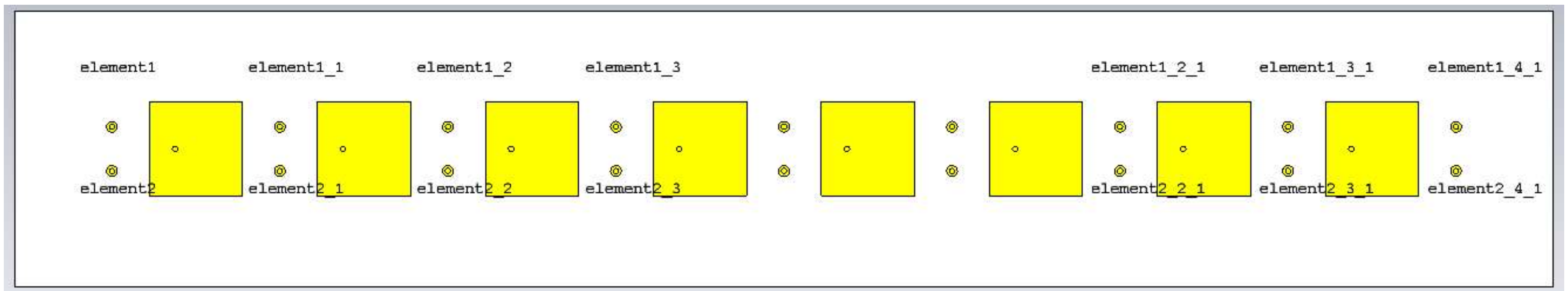

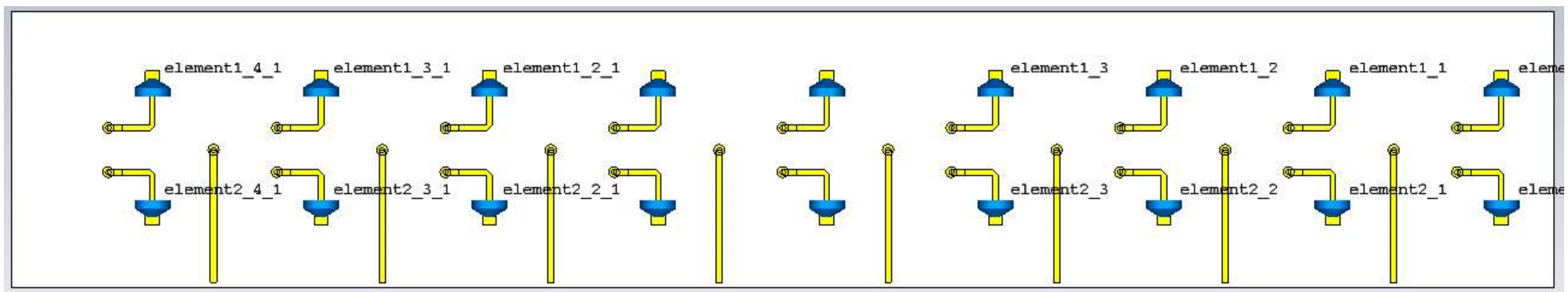

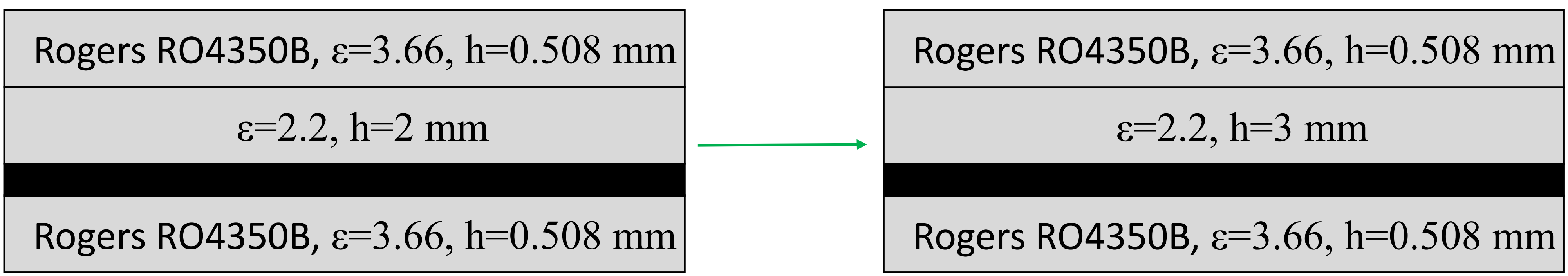

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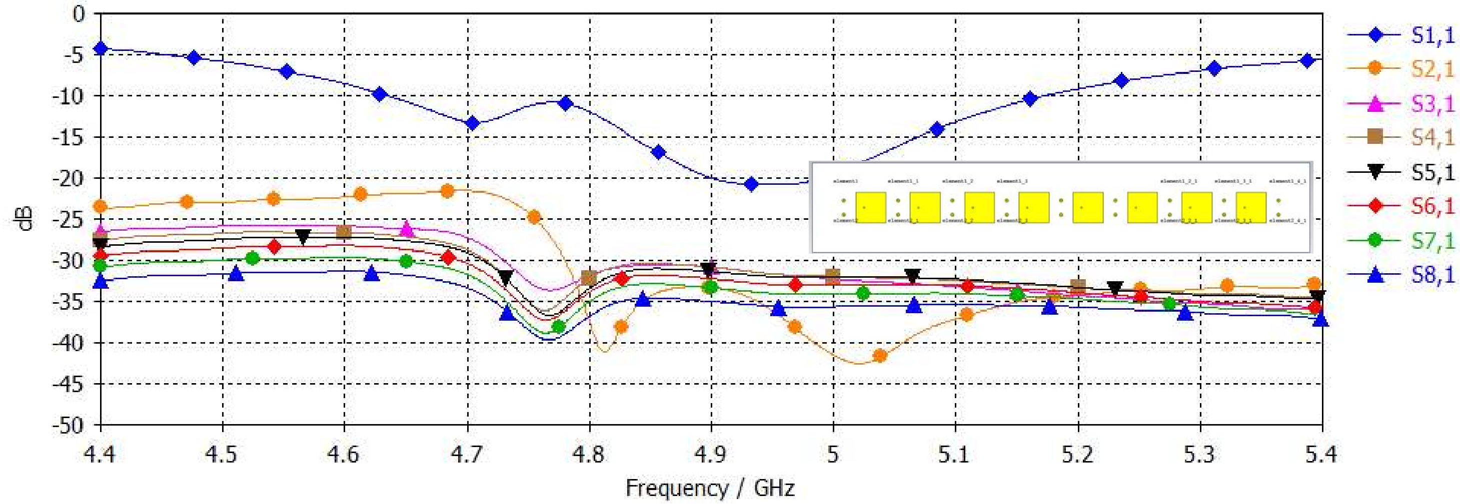
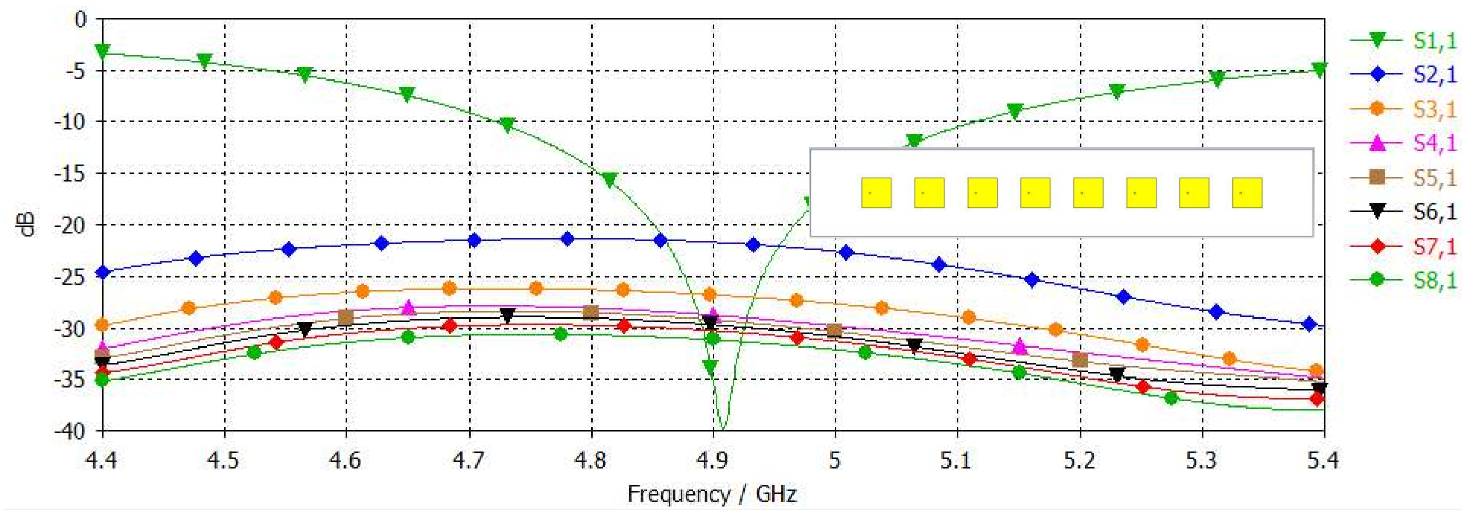
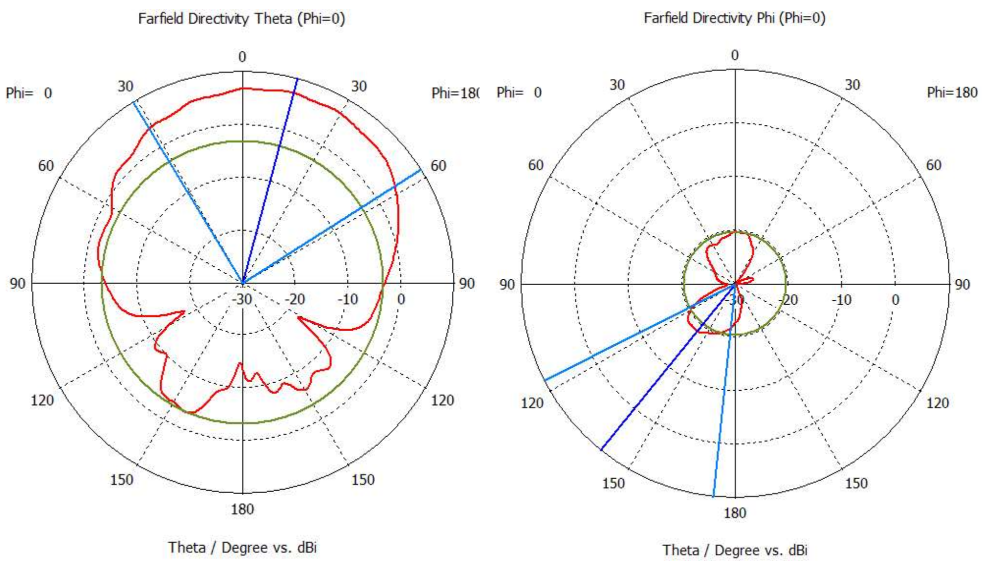


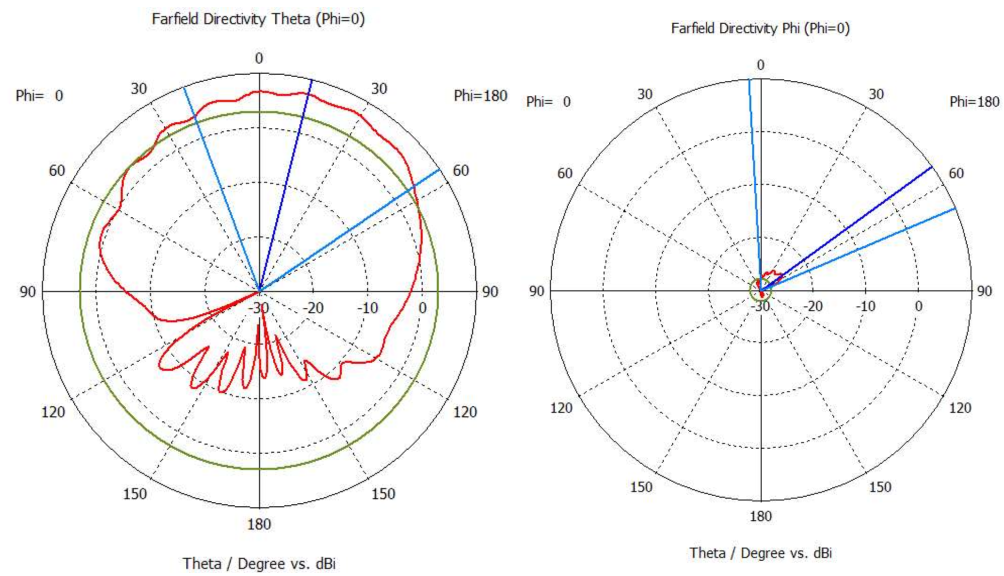


2. Wavetrap structure for wide band decoupling: Future Project

With the decoupling structure



Without the decoupling structure



Radiation patterns of element 1

Thank you !